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METHODS OF DEFENSE IN ORGANISMS.

BY CHAS. MORRIS.

Some weeks ago I presented a paper on this subject to the Academy. I wish to add a few suggestions to the considerations there taken, and particularly to speak of the evolution of the sponge, considered from the point of view of defense. As is well known, the sponge type of organism is one that it has proved difficult to classify, since it only partly conforms to the type of the Cœlenterates, while it is widely divergent from any other animal type. I may briefly point out these divergent features.

In all other animals above the Protozoans, except those parasitic forms which are destitute of an intestine, the mouth is a single aperture, which constitutes the main opening into the body. In the sponge type this single aperture is replaced by a multitude of minute openings, in connection with a single large anal opening. In one other respect the sponge is different from and more simplified than other animal types. Its digestion is entirely cellular. It has developed no organ answering to the stomach of other types.

The sponge is, moreover, destitute of any organs of offense or defense. Its nearest relatives, the polyps, have their tentacles and thread-cells, in connection with a single aperture, which is both oral and anal in function, and with a digestion which is intermediate between the cellular and the stomachal methods, and can be properly classed with neither.

The method of obtaining food, by the aid of water currents, is not peculiar to the sponge. It may be found in other animal types, such as the bivalve mollusks, the Tunicata, *Amphioxus*, etc. But in the sponge it is far more simplified than in these higher forms. In the case of the mollusks, the water current is confined to the branchiæ, and only its food particles are taken into the intestine. In the Tunicates and in *Amphioxus* respiration is intestinal, but the water current is confined to the branchial half of the intestine, while its food particles enter the stomachal half, where they undergo digestion. In the sponge the water currents permeate every portion of the body, and respiration, as well as digestion, is a function of the separate cells. Thus the most interior regions of the organism are visited by this water current and its contents.

Of all animal types, therefore, that of the sponge is least protected by defensive appliances. There is nothing in the make-up of the organism to prevent enemies from entering and penetrating to every portion of the body. They cannot be confined to an intestinal tube, and exposed to the action of its digestive juices, as in most organisms, but the whole interior of the body is open to assault.

Yet the evolution and long-continued existence of the sponge type is evidence that it has possessed some defensive adaptation. This adaptation, in its original phase at least, I take to be the peculiar system of inhalent and exhalent apertures. It is evident that the entrance of the water currents at the large aperture would greatly facilitate the entrance of the foes of the sponge, since they would be drawn from a distance and carried into the body on these currents. As it is, the currents enter at minute apertures, only adapted to the passage of microscopic food particles, and closing completely when not in use. The spicules may also act defensively, to prevent any larger creature from forcing an entrance at these oral apertures.

On the other hand, there is a strong current of outflow from the large aperture, well adapted to drive away the foes of the sponge, unless possessed of considerable swimming power. In this fact we seem to have an explanation of the peculiar organization of the sponge. The primeval ancestors of the Cœlenterates probably developed in two directions. In one type tentacles and thread-cells appeared, the oral opening was defended, and the internal cavity took on the function of an incipient stomach. In the other type the simple gastrula form was retained, and water was drawn in by ciliary action through pores in its cellular wall, and discharged at the mouth opening, after yielding its food particles to the individual cells. Thus a multitude of minute currents were combined into a single protective outflowing current of considerable strength.

This formation seems beneficial to the sponge from an aggressive as well as from a defensive point of view. The extension of the oral apertures over the whole surface of the body very considerably increases the water space from which food particles are drawn in, and thus may add materially to the food supply. As the microscopic creatures which serve the sponge for food are somewhat thinly disseminated, this extension of the space swept by the inflowing currents is certainly an advantage.

These remarks, however, are intended to apply principally to the primitive sponge. In the earliest stage of this type of organism it probably lacked the spicular and fibrous defenses now possessed, and was but a step above the simple gastrula. At this remote era, however, it is probable that muscular action had not yet been evolved, and that cilia formed the only agents of animal motion. Against creatures swimming by aid of cilia the water current of the sponge must have been fully efficacious as a defense. The development of the fibrous framework, and of the pointed spicules, was probably a subsequent adaptation to meet new dangers, after muscular organs of motion had been evolved. At present prowling animals have no difficulty in making their way to the interior of the sponge. The spicule is now probably its most efficient defense, and the continued existence of the sponge type shows that it is sufficiently defended against such animals as might seek to prey upon its protoplasmic substance.

I may offer, in conclusion, a further application of the hypothesis presented in my former paper. The interaction of attack and defense presents a feature of distinction between animals and plants, in addition to those usually recognized. This distinction I may briefly indicate.

If we consider the defensive appliances of animals from a general point of view, they may be reduced to two categories. They are either mechanical or motor. These exist together, but to the extent that the one method is developed, the other remains undeveloped. If we take such an animal as the oyster, for instance, we find that its defense is almost wholly mechanical. Its only defensive motion is one of withdrawal within the shell. If we take man, the defence is almost wholly motor. Scarcely a trace of mechanical defense exists. In my former paper I spoke also of mentality as a defensive attribute. But the defensive action of the mind yields really a motor effect. It simply produces more intricate and diversified motions, both in attack and defense, than those displayed by unintelligent animals.

If we examine the whole range of the animal kingdom, we find every phase of combination of mechanical and motor defense, the motion growing more sluggish as the defensive armor grows more efficient. But in the whole kingdom, motion persists as one of the defensive agencies. No animal exists without some power of motion, by whose aid it withdraws or otherwise escapes from danger.

In the plant kingdom, on the contrary, no defensive motion exists. Mechanical defense exists alone. This does not apply to those minute swimming organisms which lie near the root of the plant and animal kingdoms. But in all the higher plants no motion exists, so far as I am aware, that is useful as a protection. Thus the possession of protective motions by all animals, and the lack of them by all plants, serve as a point of distinction between the two kingdoms.

In regard to aggressive motions, this rule does not so fully hold good. All animals have aggressive motions. Nearly all plants are destitute of them. Yet a few plants possess them. We have instances of aggressive motions in the case of the creeping Fungi, and of the Insectivorous plants. Yet apart from these cases, the plant kingdom seems devoid of motions useful either for attack or defense, and trusts wholly to mechanical appliances. With the mechanical, however, must be included chemical appliances, as in the case of poisonous or disagreeable juices.

One more query remains. Why, in the early days of the animal kingdom, as known to us, was there such a marked tendency to trust to mechanical defense, while in the later era the tendency has been towards motion as the main protective agent? If we consider the early conditions of animal life, this is not difficult to comprehend. There is every reason to believe that the various organs of animals were very slowly evolved. In a former communication I have advanced the hypothesis that the early animals were for a long time naked forms, partly, at least, through lack of the evolution of glands necessary to produce hard coverings. These early animals also moved by means of cilia only, if we can trust the evidences from embryology, and from the lower existing forms. The development of nerves and muscles was a very slow process. The evolution of a form and of swimming organs giving high efficiency to muscular action, was probably much slower. The early animals possessed of muscles had probably a very inefficient motor apparatus, and were very sluggish in their movements. With the development of armor-producing power, therefore, this seems to have been very generally employed as a defense of the sluggish against such swifter moving carnivorous animals as may have arisen. One great superiority of the vertebrate type has always been the superior suitability of its form and motor organs to swift movement, and it seems quite likely that the great variety of mechanically defended lower forms in the early fossiliferous beds, is due to the existence of swift-moving antique vertebrates, which were themselves nearly or quite destitute of hard parts, capable of preservation. Though a later " struggle for existence," between vertebrates themselves, caused the weakest and least active of these to develop armor, yet it was succeeded by a general tendency in this type of life to discard mechanical defenses, and trust to motion for protection. The same has been the case with the actively aggressive members of some of the lower types, such as the higher mollusks, which have thrown off their armor, and developed other defensive appliances.

Throughout the whole history of the organic realm one principle holds good. There has been a continued evolution of more rapid and varied powers of motion. To this, every advance in organization has tended, while the hindrances to speed and flexibility have been successively discarded by the higher forms of life. In correspondence with this has been the development of mentality, since mentality, as outwardly displayed by the animals below man, is indicated by a greater intricacy of motions, in combination with ambush and concealment. For the attainment of the highest possible speed and strength, little mentality was requisite, and brain development is manifested rather by intricacy than by speed of motion—or rather by that well-ordered correlation of rest and diversified motion suited to the best good of the organism. Yet we must regard mentality as rather the effect than the cause of motor evolution. Probably the power of diversified motion appeared first, while the exercise of any new power of this kind acted as an agent in the development of the brain. In other words, the evolution of the brain is a consequence of that of the body—not the reverse.